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(54) **COVERGLASS FRACTURE DETECTION**

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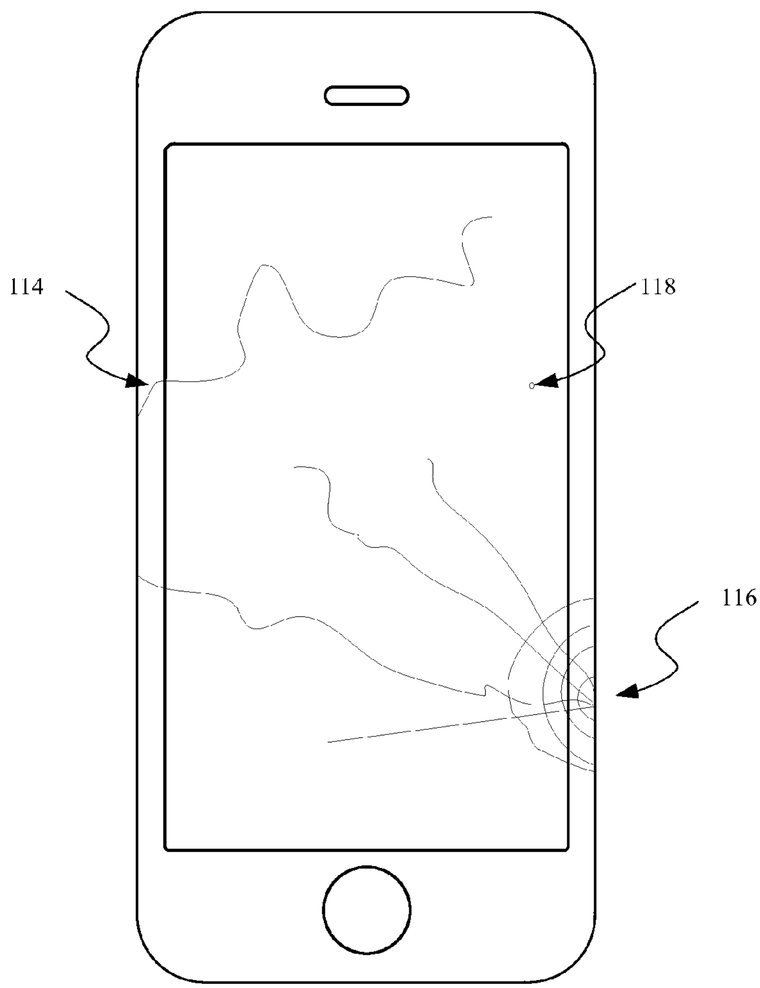
(57) **ABSTRACT**

This application relates to methods and apparatus for detecting and characterizing the formation of cracks in a display cover. Various types of sensors can be used to accomplish the described embodiments. For example, a touch sensor can be utilized for detection and characterization purposes. Alternatively, a crack detection specific sensor or sensors can be added to a device. In some embodiments, when formation of a crack is detected, a device having a sensor that detects a crack can adjust its behavior depending upon how the crack is characterized. For example, the device can be configured to notify a user of the device of any or all systems of the device that will be affected by the detected crack. In some embodiments, crack characterization data can be sent to a device manufacturer to improve subsequent device models.



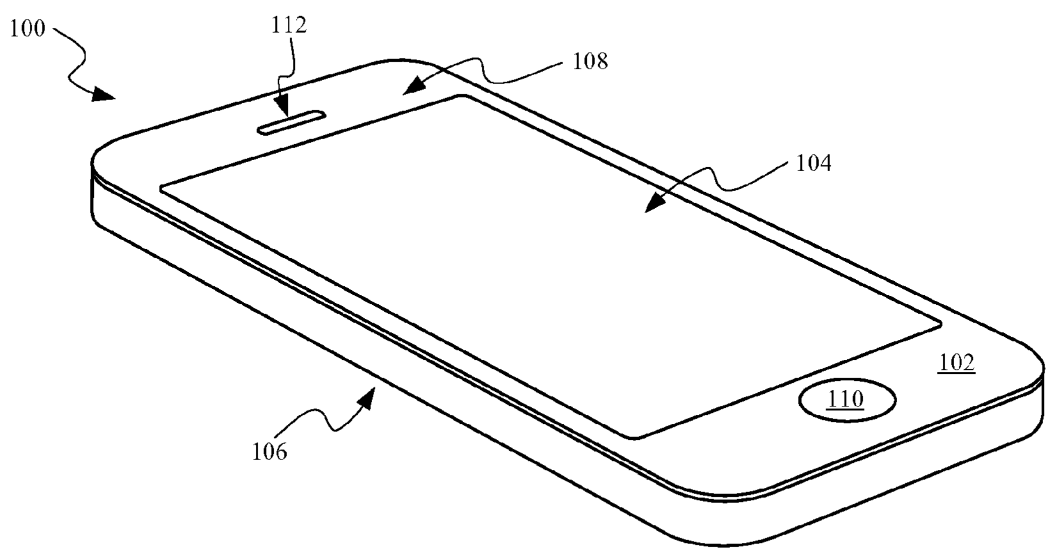


FIG. 1A

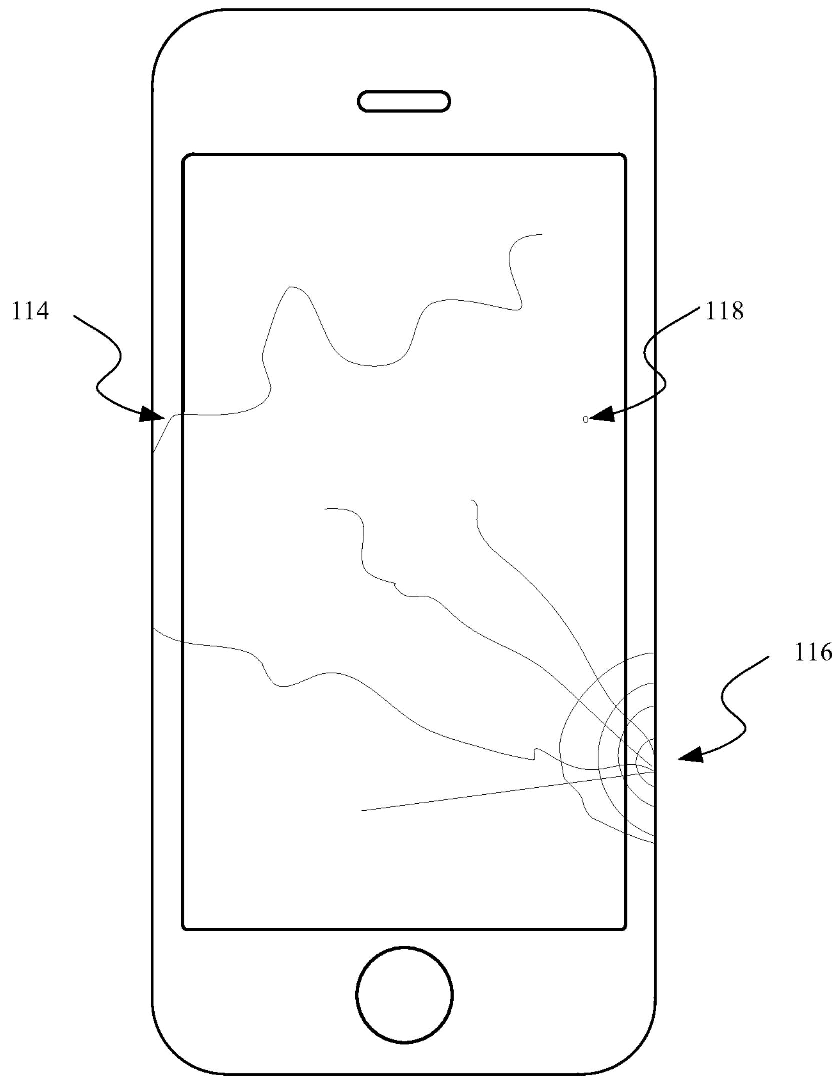


FIG. 1B

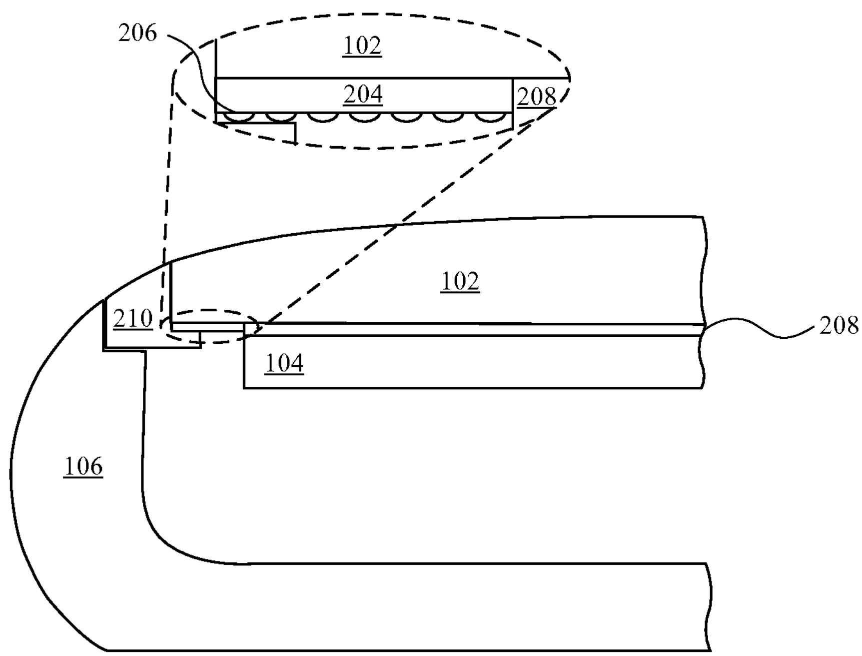


FIG. 2

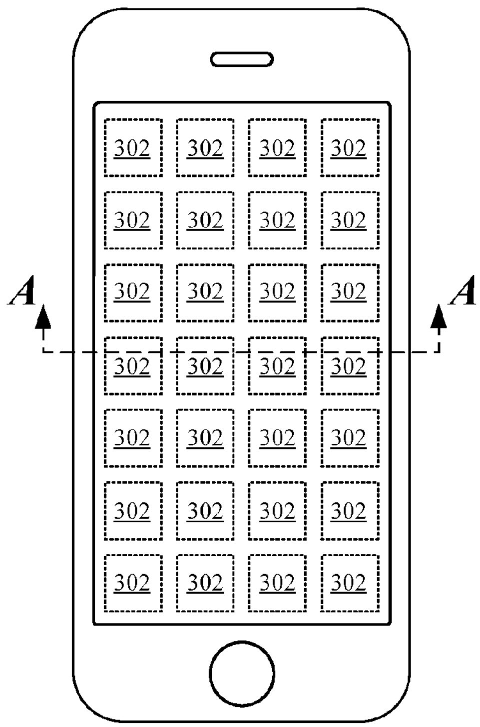


FIG. 3A

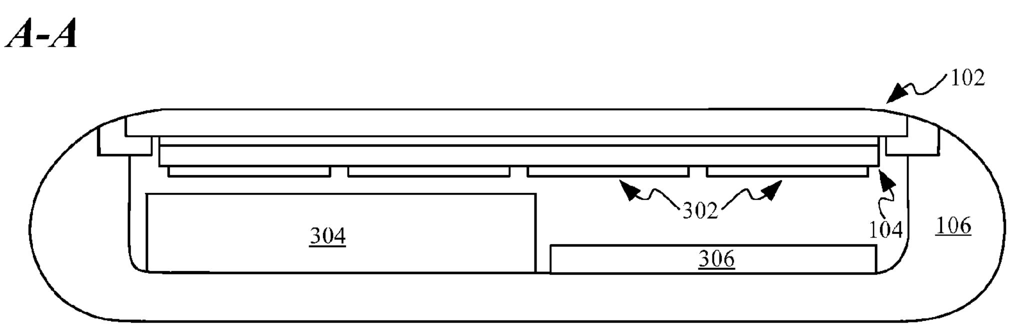
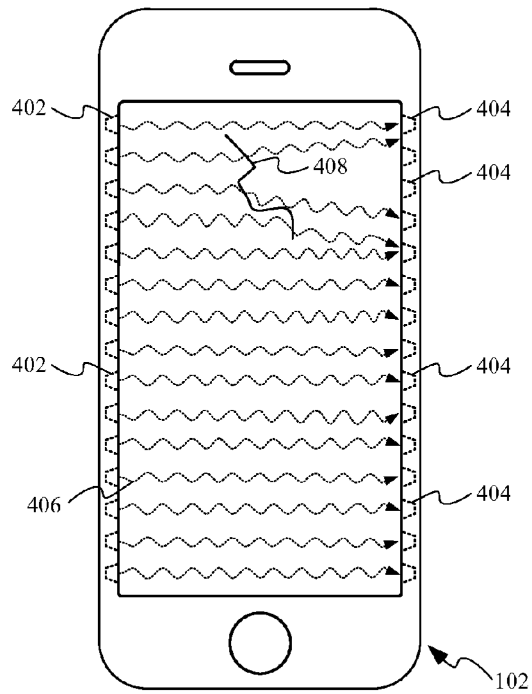
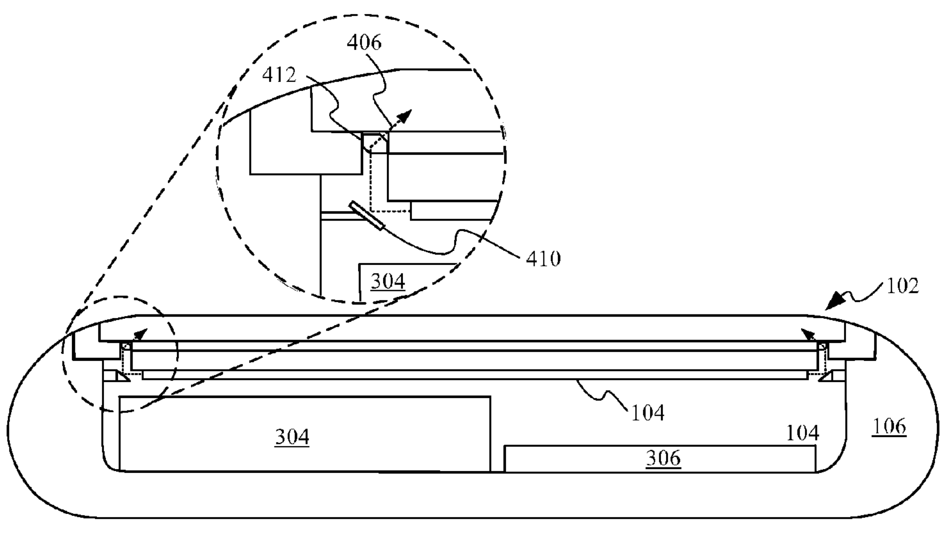


FIG. 3B



402
404
408
404
402
404
406
404
102

FIG. 4A



406
412
410
304
102
104
104
106
304
306

FIG. 4B

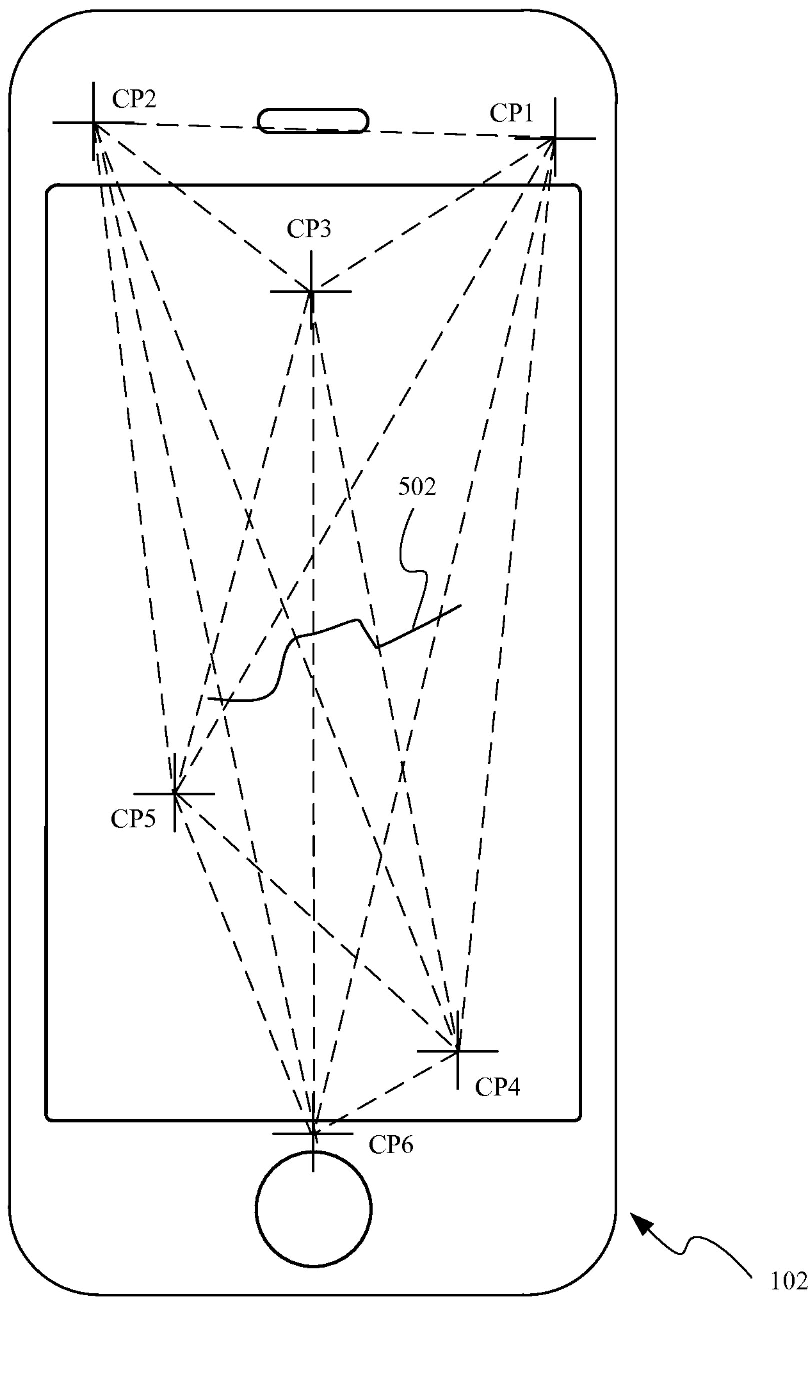


FIG. 5

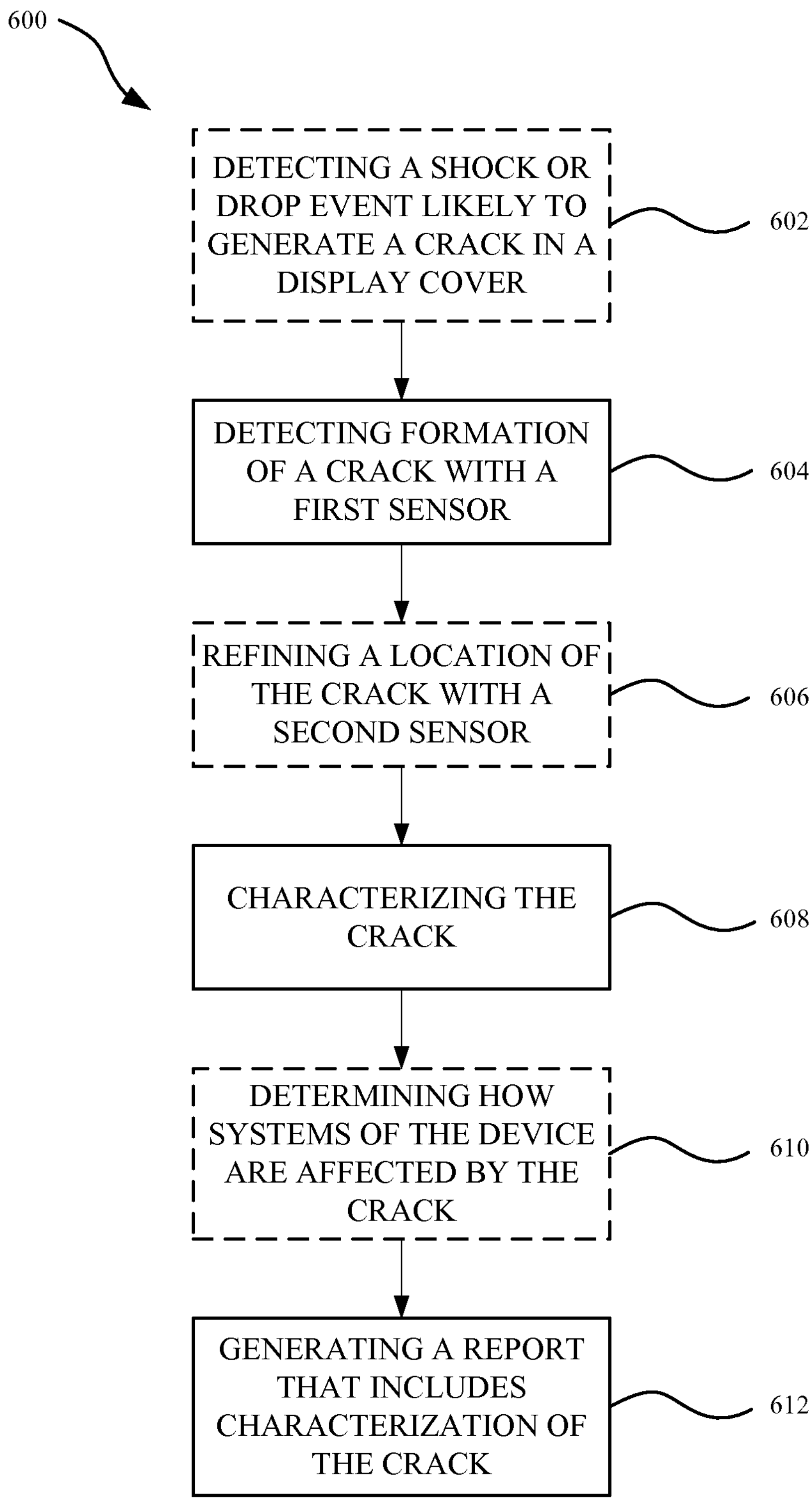

600
DETECTING A SHOCK OR DROP EVENT LIKELY TO GENERATE A CRACK IN A DISPLAY COVER
602
DETECTING FORMATION OF A CRACK WITH A FIRST SENSOR
604
REFINING A LOCATION OF THE CRACK WITH A SECOND SENSOR
606
CHARACTERIZING THE CRACK
608
DETERMINING HOW SYSTEMS OF THE DEVICE ARE AFFECTED BY THE CRACK
610
GENERATING A REPORT THAT INCLUDES CHARACTERIZATION OF THE CRACK
612

FIG. 6

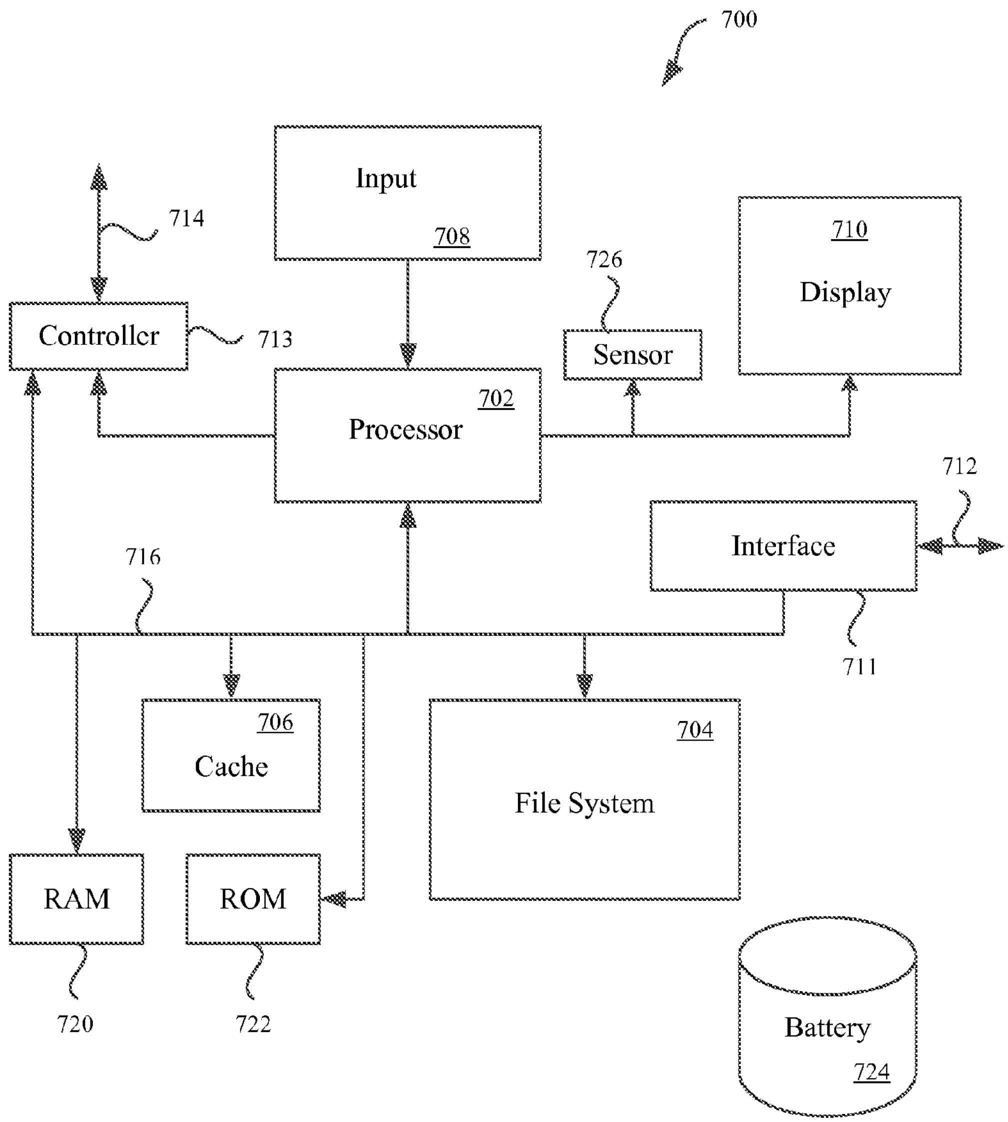

700
Input
708
714
Controller
713
726
Sensor
710
Display
702
Processor
712
Interface
716
711
706
Cache
704
File System
RAM
ROM
720
722
Battery
724

FIG. 7

COVERGLASS FRACTURE DETECTION

FIELD

[0001] The described embodiments relate generally to methods for detecting damage to a portable electronic device. More particularly, the present embodiments include methods and apparatus for detecting the creation of cracks in a display cover of the portable electronic device and for modifying behavior of the portable electronic device in response to the detection.

BACKGROUND

[0002] Portable electronic devices are generally built to withstand any number of stresses and strains caused by daily use. Due to the portable nature of these devices, the portable electronic devices are likely to be subjected to drops and impacts of varying severities. While various ways of reinforcing and strengthening these devices to account for these types of events have been developed, certain portions of the devices can still remain quite susceptible to breakage and/or degradation. In particular, the display cover or coverglass portion of a portable electronic device can be an area in which damage is likely when the portable electronic device is dropped or subjected to a high impact force. Forces acting upon the coverglass can cause any number of different types of breaks and/or cracks to occur in the coverglass. Unfortunately, device designers are often unable to get much data about how and in what circumstances a coverglass component is most likely to break. For this reason, the device designers do not always have the data necessary to add features to the device that can help to mitigate coverglass breakage in common fall scenarios.

SUMMARY

[0003] This paper describes various embodiments that relate to systems suitable for detecting and characterizing cracks propagating through a display cover of a portable electronic device.

[0004] A portable electronic device is disclosed. The portable electronic device includes at least the following: a device housing; a display cover coupled with the device housing; a processor; and a crack detection system disposed within the device housing and electrically coupled with the processor. When the crack detection system detects a crack in the display cover, the processor alters operation of the portable electronic device.

[0005] Another portable electronic device is disclosed. The portable electronic device includes at least the following: a housing including a housing component and a display cover; a display assembly disposed beneath the display cover; a crack detection sensor arranged adjacent to the display assembly. The crack detection sensor periodically measures light refracted by the display cover during operation of the portable electronic device.

[0006] An electronic device is disclosed. The electronic device includes at least the following: a device housing; a display cover overlaying a display assembly disposed within the device housing; a device orientation system; and a crack detection system. The crack detection system is configured to change from a first state to a second state in response to determination by the device orientation system that an event likely to damage the display cover is imminent or has just occurred.

[0007] Other aspects and advantages of the invention will become apparent from the following detailed description taken in conjunction with the accompanying drawings which illustrate, by way of example, the principles of the described embodiments.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] The disclosure will be readily understood by the following detailed description in conjunction with the accompanying drawings, wherein like reference numerals designate like structural elements, and in which:

[0009] FIG. **1**A shows an exemplary device suitable for use with the described embodiments;

[0010] FIG. **1**B shows the exemplary device depicted in FIG. **1**A after a number of cracks have propagated through a display cover of the exemplary device;

[0011] FIG. **2** shows a partial cross-sectional view of the exemplary device;

[0012] FIG. **3**A shows a top view of a coverglass fracture detection system in which an array of piezoelectric actuators are attached to the display assembly;

[0013] FIG. **3**B shows a cross-sectional view of the coverglass fracture detection system of FIG. **3**A;

[0014] FIG. **4**A shows an embodiment in which light is utilized to detect and characterize cracks propagating through the display cover;

[0015] FIG. **4**B shows an additional embodiment in which light from within the exemplary device is redirected so that the light refracts through the display cover;

[0016] FIG. **5** shows another way in which cracks or fractures forming in the display cover can be characterized;

[0017] FIG. **6** shows a flowchart depicting a method for detecting the propagation of cracks in a display cover of an electronic device; and

[0018] FIG. **7** shows a block diagram of an electronic device suitable for use with the described embodiments.

DETAILED DESCRIPTION

[0019] Representative applications of methods and apparatus according to the present application are described in this section. These examples are being provided solely to add context and aid in the understanding of the described embodiments. It will thus be apparent to one skilled in the art that the described embodiments may be practiced without some or all of these specific details. In other instances, well known process steps have not been described in detail in order to avoid unnecessarily obscuring the described embodiments. Other applications are possible, such that the following examples should not be taken as limiting.

[0020] In the following detailed description, references are made to the accompanying drawings, which form a part of the description and in which are shown, by way of illustration, specific embodiments in accordance with the described embodiments. Although these embodiments are described in sufficient detail to enable one skilled in the art to practice the described embodiments, it is understood that these examples are not limiting; such that other embodiments may be used, and changes may be made without departing from the spirit and scope of the described embodiments.

[0021] Portable electronic devices are generally designed to accommodate varying degrees of stress generated by unintentional drops and unintentional impacts. While many systems inside these devices are well protected from an application of moderate force, many devices are most vulnerable to damage resulting from a large impact being applied to a display cover or coverglass. Even though coverglass technology has enjoyed rapid development leading to increasingly durable glass and plastic materials, the coverglass component continues to be one of the most likely components at which a device receives substantial damage when the device is subjected to externally applied forces. Unfortunately, device manufacturers are not always able to determine what event or series of events lead to the formation of a crack or cracks in the coverglass.

[0022] One way to help to mitigate problems associated with breakage or damage to the coverglass is to develop a new sensor or adapt an existing sensor for detecting incidents of coverglass breakage. In some embodiments, sensors within the device can be configured to detect any fracture or cracks propagating through the coverglass. Sensors suitable for detection of coverglass breakage can include a touch sensor when the touch sensor is in direct contact with an interior facing surface of the coverglass. Such a configuration can allow for precise determination of a position of any cracks propagating through the coverglass, since any cracks propagating through the coverglass may also separate portions of a sensor grid of the touch sensor. In some embodiments, orientation sensors within the device can be used to generate alerts that direct the device to initiate a scan of the sensors associated with the breakage detection system to determine the following: (1) whether or not there had been a breakage; and (2) how severe any detected fractures had been. For example, when the accelerometer or other spatial/orientation detection sensors detect a deceleration of the device consistent with a fall, those sensors could send a message to the processor. In response to the message, the processor could then initiate a sensor scan for cracks in the display cover. In many embodiments, detection of a crack can be assumed when a significant change in readings from the crack detection system occurs. In some embodiments, data stored within the device can be used to correlate the changes in readings with likely positions of cracks in the display cover.

[0023] Once the cracks are detected, any number of actions can be subsequently performed by the device. In some embodiments, a simple message could be sent to a user of the device, informing the user the display glass has been broken. This notification could be very beneficial in cases of a hairline crack where a user might not even realize the presence of a crack. In some embodiments, diagnostic data describing the conditions before and after formation of the crack could be sent to a manufacturer of the device to help optimize future devices so that they are better adapted to resist display cover cracking. In some embodiments, a more detailed message could be sent to a user of the device informing that user of any sensors or systems that would be affected or disabled due to cracking of the display cover. In some embodiments, a user can be asked to confirm a location at which a crack or fracture of the display cover had occurred. Confirmation of the crack could include for example asking the user to confirm a crack location highlighted by a display of the device or asking the user to circle or otherwise indicate a crack location with a touch input.

[0024] These and other embodiments are discussed below with reference to FIGS. **1A-6**; however, those skilled in the art will readily appreciate that the detailed description given herein with respect to these figures is for explanatory purposes only and should not be construed as limiting.

[0025] FIG. **1A** shows an exemplary device **100** suitable for use with the described embodiments. As depicted a display cover **102** defines a substantial portion of a top surface of device **100**. Display cover **102** can also be referred to as coverglass and can be formed of a durable transparent material along the lines of glass or plastic. Display cover **102** provides a cosmetically and tactilely pleasing surface upon which user inputs can be received. Display cover **102** can overlay display assembly **104**, which is contained within and protected by display cover **102** and housing component **106**. In some embodiments display assembly **104** can be a touch sensitive display assembly. The touch sensors driving the touch sensitivity can be positioned in many locations. In some embodiments, the touch sensor can be integrated into display assembly **104** and in other embodiments at least a portion of the touch sensor can be applied to an interior facing surface of display cover **102**. In some embodiments, masked regions **108** of display cover **102** can be masked by, for example, an amount of ink selectively positioned upon the interior facing surface of display cover **102**. The ink can be applied to display cover **102** in a manner so that the only transparent portion of display cover **102** is that portion that overlays an active display portion of display assembly **104**. Various colors of ink can be used. Display cover **102** can also define a number of openings. For example, one opening can be configured to allow a user access to button **110**. Another opening **112** can be configured to allow audio content generated by a speaker component within housing component **106** to leave device **100** while device **100** is being used as a phone.

[0026] FIG. **1B** shows the exemplary device depicted in FIG. **1A** after a number of cracks have propagated through display cover **102**. The cracks depicted in FIG. **1B** show different types and severities of cracking. Hairline crack **114** is a single line crack that can have less impact upon a device than webbed cracking **116**. With webbed cracking a lattice of cracks can be formed from a severe enough impact, in some cases causing substantial chips of glass to be released from device **100**. In some embodiments, a crack detection system disposed within device **100** can be configured to distinguish between hairline and webbed cracking. In some embodiments the crack detection system can also determine what percentage of display cover **102** is covered in cracks. In still other embodiments, crack detection systems can be configured to detect the presence of chipped area **118** appearing along an exterior surface of display cover **102**. The device could be configured to reassure a user when a chipped area of display cover **102** does not extend entirely through display cover **102**. In such a case a user can be reassured when no other impacts to functionality of the device result.

[0027] FIG. **2** shows a partial cross-sectional view of electronic device **100**. In some embodiments, display cover **102** can include a number of masked regions **108** as depicted in FIG. **1A**. Masked regions **108** can be defined by masking material **204** disposed upon an interior facing surface of display cover **102**. Masking material **204** can take many forms including optically opaque paint or ink. In some embodiments, capacitive elements **206** can take the form of indium tin oxide or silver ink/particles. Indium tin oxide has the advantage of being optically transparent and electrically conductive. In some embodiments, a touch sensor array associated with display assembly **104** is used to detect and characterize cracks in display cover **102**. This configuration can be used when the touch sensor array is in direct contact with an interior facing surface of display cover **102**. When a crack propagates through display cover **102**, the cracking can also sever connections in the touch sensor array. These severed connections in the touch sensor array can be monitored to obtain detailed information about propagation of the cracks.

[0028] Display assembly **104** can be coupled to display cover **102** by adhesive layer **208**. In some embodiments, adhesive layer **208** can be a liquid optically clear adhesive so that transmission of an image produced by display assembly **104** is not obscured. In some embodiments, an interface between display cover **102** and housing component **106** can be formed by environmental seal **210**, which can help to prevent the passage of foreign objects or contaminates between display cover **102** and housing component **106**. It should be noted that if the touch sensor is limited to an area overlaying display assembly **104**, then the use of the touch sensor as the sole means of monitoring cracking of display cover **102** would limit the ability of the devices ability to detect and characterize cracks forming in masked regions **108** of display cover **102**. In some embodiments, substantially all of display cover **102** can be monitored for cracks by combining inputs from a touch sensor associated with display assembly **104** and capacitive elements **206** taking the form of beads of silver ink or particles embedded within masked regions **108**. In some embodiments, a touch sensor associated with display assembly **104** can expanded out past an active display region of display assembly **104** so that the touch sensor covers both the portion of display cover **102** that overlays an active display region of display assembly **104** and masked regions **108** of display cover **102**. In this way, any cracking of any portion of display cover **102** can be monitored. It should be noted that in embodiments, where a touch sensor is integrated with display assembly **104**, additional sensors may be needed to monitor portions of display cover **102** overlaying the active display region of display assembly **104**. In some embodiments, display cover **102** can include indium tin oxide particles adhered to or embedded within display cover **102** to accomplish the function of monitoring for cracks propagating through display cover **102**.

[0029] FIGS. **3**A-**3**B show another coverglass fracture detection embodiment in which an array of piezoelectric actuators are positioned below display assembly **104**. FIG. **3**A shows a top view of electronic device **100** and how piezoelectric actuators **302** can be arranged in a grid pattern within electronic device **100**. In this way, piezoelectric actuators **302** can send out vibrations targeted at various portions of display cover **102**. While the sensors are only shown below the display portion it should be understood that they could also be arranged beneath masked portions. By using an additional sensor or one integrated within piezoelectric actuator **302** to measure the vibrations returned by the display cover a baseline can be created either upon manufacturing completion or periodically during operation of the device to account for any minor changes due to wear on the device. By periodically monitoring the vibratory response of different portions of display cover **102**, substantial differences in the vibratory response can be detected and classified as cracks or potential cracks. Periodic monitoring of the display cover response to the vibrations can even include embodiments in which the vibratory response is measured subsequent to use of one or more piezoelectric actuators for other operational purposes. In some embodiments, other sensors can be combined with this detection method to further refine crack data detected in this way. In some embodiments, these checks can be limited to situations in which a fall or drop event has occurred since vibration of each actuator can affect the user experience and if done at frequent intervals even adversely affect battery life.

[0030] FIG. **3**B shows a cross-sectional view of device **100** in accordance with section line A-A of FIG. **3**A and shows how piezoelectric actuators **302** can be positioned along an interior facing surface of display assembly **104**. By packaging piezoelectric actuators **302** in a thin form factor the piezoelectric actuators can have only a minor effect on overall free space available within the device for other components or space for cooling channels. Components disposed within device **100** can include for example, battery **304** and printed circuit board **306**. It should be noted that while an array of piezoelectric actuators are depicted that in some embodiments a single vibratory motor could be used and that changes in the vibratory response could be used as a first indication of the presence of a crack in the display cover when the vibratory response of the display cover is substantially different. For example, in some embodiments a unitary vibratory motor can be configured to record a response of the display cover to vibrations generated by the vibratory motor.

[0031] FIG. **4**A shows an embodiment in which light is utilized to detect and characterize cracks propagating through display cover **102**. In FIG. **4**A, electronic device **100** is depicted having an array of light emitting devices **402** arranged at one end of display cover **102** that emit light that travels across display cover **102**. In some embodiments, light emitting devices **402** take the form of light emitting diodes and can transmit light through display cover **102** without substantially effecting output of display assembly **104** through display cover **102**. In configurations where continuous illumination of display cover **102** by light emitting devices **402** does effect the output of display assembly **104**, light emitting devices **402** can be configured to emit only short bursts of light **406** unlikely to affect display output. One advantage of periodically pulsing the light is that an amount of energy expended by light emitting devices **402** can be minimized. In some embodiments, as described above light emitting devices **402** may only emit light **406** in response to some other stimulus, such sensor readings showing indications of drop and/or shock events. Light detecting devices **404** can be arranged opposite light emitting devices **402** and can characterize how much and in what direction light emitted from light emitting devices **402** arrives at light detecting devices **404**. In some embodiments, light **406** from light emitting devices **402** can be polarized so that any change in orientation of the light waves by cracks and/or imperfections in the glass are further accentuated. In some embodiments, light **406** emitted by the light emitting device **402** can be pulsed in a recognizable pattern so that light from light emitting devices **402** can be differentiated from light entering display cover **102** from another source. For example, circuitry associated with light detecting devices **404** can be arranged to ignore any detected light not pulsed at a predetermined frequency. When the pulse modulation of the light beam is different for each light emitting device **402**, the differences in pulse modulation can also be used to determine which light emitting device **402** emitted the detected light to better help characterize defects within display cover **102**. In some embodiments, both light emitting devices **402** and light detecting devices **404** can both be configured to both emit and detect light. It should also be noted that while numerous emitters and detectors are depicted, the system can be configured to operate with as few as one emitter and one detector. FIG. **4**A also shows how crack **408** diverts some of light **406** as it exits crack **408**. The deflection of light **406** from a path it would normally take in the absence of crack **408** can be used to determine at least an approximate location of crack **408**.

[0032] FIG. **4**B shows an additional embodiment in which light from within device **100** is redirected so that the light refracts through display cover **102**. This variation can be accomplished by distributing prisms and/or mirrors within device **100**. In some embodiments, as depicted, light **406** bleeding out of peripheral edges of display assembly **104** can be redirected by mirror **410** and prism **412**. In other embodiments, light emitting devices **402** can be embedded farther away from display cover **102** and using mirrors **410** and/or prisms **412** the light from light emitting devices **402** can be redirected to enter at or near one end of display cover **102**. The light detection method may have the advantage of being able to detect chips in display cover **102** in addition to hairline fractures and cracks that propagate through an interior surface of display cover **102**. It should be noted that in some embodiments, an existing sensor along the lines of an ambient light sensor can be configured to detect changes in reflectance of nearby portions of display cover **102**.

[0033] FIG. **5** shows another way in which cracks or fractures forming in display cover **102** can be characterized. An array of contact points CP**1**-CP**6** can be distributed across display cover **102** as depicted. Each of the contact points can be configured to measure a resistance of display cover **102** between contact points. A change in resistance between the contact points can be indicative of crack formation between the contact points. For example, when a fracture or crack **502** runs through the direct path between each of the contact points, represented by the dotted lines the electrical resistance can change. This change in resistance can be detected and interpreted by a processor as a signal By receiving the various signals and determining which contact points do or do not experience changed resistances a location of the crack can at least be approximated. For example, because resistance between CP**1**, CP**2** and CP**3** the crack is not running through an upper portion of display cover **102**. By adding a larger numbers of contact points characterization of crack **502** can be accomplished with greater precision. While the contact points are distributed in both active and masked portions of display cover **102** it should be appreciated that the contact points can be arranged entirely within the masked portions or the active portions. It should be understood that feedback from each of the contact points can be communicated to additional circuitry disposed on for example a printed circuit board below display cover **102** by way of a flexible circuit extending from a connector or connection point on display cover **102** and a connector on the printed circuit board.

[0034] FIG. **6** shows a flow chart depicting a method **600** for characterization of a crack in a display cover. In a first optional step **602**, motion sensors of an electronic device along the lines of accelerometers, gyroscopes and barometers can all be utilized together or individually to provide real-time feedback regarding physical positioning, orientation and forces acting upon a device. These inputs can be used to identify situations in which a crack is likely to be formed in a display cover. For example, when the accelerometer detects a device is in free fall, sensors can be activated to gather detailed information just prior to and after an impact ending the free-fall event. At step **604**, crack detection specific sensors may only be activated or configured to send crack sensing data to a processor when cued by the aforementioned orientation sensors. In other embodiments, the crack detection specific sensors can begin sampling at higher rates when cued by the motion sensors. At optional step **606**, an additional sensor or sensors can be activated in response to the first sensor determining the propagation of at least one crack or fracture in the display cover. The additional sensor can be configured to provide additional detail and/or different characteristics regarding the detected crack than the one initially detected by the first sensor. At step **608**, the characterization data received by the first and/or second sensors can be transmitted to a processor for analysis. Once the processor analyzes depth, length, width and propagation rate data collected from the sensors, additional actions can be taken. At optional step **610**, the crack propagation data can be used to determine whether any systems of the device are affected by formation of the crack. In some embodiments, the certain functionality of the device can be disabled to avoid inaccurate readings or to prevent additional damage to the device. At step **612**, the crack creation/propagation data can be associated with any motion data collected and sent out as diagnostic data for collection by device manufacturers, or in some embodiments sent off to warranty entities to assist in making warranty eligibility determinations. In some embodiments, a user can be prompted to confirm locations of cracks identified by the sensor system. In other embodiments, a user could be asked to provide brief survey results regarding in what way the device had incurred its cracks/fractures. In some embodiments, in addition to or in lieu of sending diagnostic data, a message can be sent to a user of the device alerting that user of any problems or reduced functionality being caused by the crack.

[0035] FIG. **7** is a block diagram of an electronic device suitable for controlling some of the processes in the described embodiment. Electronic device **700** can illustrate circuitry of a representative computing device. Electronic device **700** can include a processor **702** that pertains to a microprocessor or controller for controlling the overall operation of electronic device **700**. Electronic device **700** can include instruction data pertaining to operating instructions in a file system **704** and a cache **706**. File system **704** can be a storage disk or a plurality of disks. In some embodiments, file system **704** can be flash memory, semiconductor (solid state) memory or the like. The file system **704** can typically provide high capacity storage capability for the electronic device **700**. However, since the access time to the file system **704** can be relatively slow, the electronic device **700** can also include cache **706**. The cache **706** can include, for example, Random-Access Memory (RAM) provided by semiconductor memory. The relative access time to the cache **706** can substantially shorter than for the file system **704**. However, cache **706** may not have the large storage capacity of file system **704**. Further, file system **704**, when active, can consume more power than cache **706**. Power consumption often can be a concern when the electronic device **700** is a portable device that is powered by battery **724**. The electronic device **700** can also include a RAM **720** and a Read-Only Memory (ROM) **722**. The ROM **722** can store programs, utilities or processes to be executed in a non-volatile manner. The RAM **720** can provide volatile data storage, such as for cache **706**.

[0036] Electronic device **700** can also include user input device **708** that allows a user of the electronic device **700** to interact with the electronic device **700**. For example, user input device **708** can take a variety of forms, such as a button, keypad, dial, touch screen, audio input interface, visual/image capture input interface, input in the form of sensor data, etc. Still further, electronic device **700** can include a display **710** (screen display) that can be controlled by processor **702** to display information to the user. Data bus **716** can facilitate data transfer between at least file system **704**, cache **706**, processor **702**, and controller **713**. Controller **713** can be used to interface with and control different sensors and electrical components with equipment control bus **714**. For example, control bus **714** can be used to control a display of data on a display in addition to audio and/or video output. For example, processor **702**, upon a certain event occurring, can supply instructions to control another component through controller **713** and control bus **714**. Such instructions can be stored in file system **704**, RAM **720**, ROM **722** or cache **706**.

[0037] Electronic device **700** can also include a network/bus interface **711** that couples to data link **712**. Data link **712** can allow electronic device **700** to couple to a host computer or to accessory devices. The data link **712** can be provided over a wired connection or a wireless connection. In the case of a wireless connection, network/bus interface **711** can include a wireless transceiver. Sensor **726** can take the form of circuitry for detecting any number of stimuli. For example, sensor **726** can take the form of the crack detection sensor described herein and can provide periodic reports to processor **702**, which can be used to adjust overall performance of device **700** in response to a determination that a display cover of display **710** has cracked or fractured. In some embodiments, processor **702** is configured to instruct sensor **726**, which can include a number of different crack detection sensors to provide further characterization of a detected crack by using different sensors to characterize it.

[0038] The various aspects, embodiments, implementations or features of the described embodiments can be used separately or in any combination. Various aspects of the described embodiments can be implemented by software, hardware or a combination of hardware and software. The described embodiments can also be embodied as computer readable code on a computer readable medium for controlling manufacturing operations or as computer readable code on a computer readable medium for controlling a manufacturing line. The computer readable medium is any data storage device that can store data which can thereafter be read by a computer system. Examples of the computer readable medium include read-only memory, random-access memory, CD-ROMs, HDDs, DVDs, magnetic tape, and optical data storage devices. The computer readable medium can also be distributed over network-coupled computer systems so that the computer readable code is stored and executed in a distributed fashion.

[0039] The foregoing description, for purposes of explanation, used specific nomenclature to provide a thorough understanding of the described embodiments. However, it will be apparent to one skilled in the art that the specific details are not required in order to practice the described embodiments. Thus, the foregoing descriptions of specific embodiments are presented for purposes of illustration and description. They are not intended to be exhaustive or to limit the described embodiments to the precise forms disclosed. It will be apparent to one of ordinary skill in the art that many modifications and variations are possible in view of the above teachings.

What is claimed is:

1. A portable electronic device, comprising:

a device housing;

a display cover coupled with the device housing;

a processor; and

a crack detection system disposed within the device housing and electrically coupled with the processor,

wherein when the crack detection system detects a crack in the display cover, the processor alters operation of the portable electronic device.

2. The portable electronic device as recited in claim **1**, wherein altering operation of the portable electronic device comprises providing a notification to a user of the portable electronic device that the crack has been detected.

3. The portable electronic device as recited in claim **1**, wherein the crack detection system comprises a touch sensor.

4. The portable electronic device as recited in claim **3**, wherein the touch sensor is integrated into an interior facing surface of the display cover.

5. The portable electronic device as recited in claim **1**, wherein altering operations of the portable electronic device comprises disabling a sensor of the portable electronic device degraded by the detected crack.

6. The portable electronic device as recited in claim **5**, wherein the crack detection system comprises an array of conductive traces disposed beneath a masked portion of the display cover.

7. The portable electronic device as recited in claim **1**, wherein the crack detection system comprises an array of piezoelectric actuators disposed beneath a display of the portable electronic device.

8. The portable electronic device as recited in claim **7**, wherein the array of piezoelectric actuators detect cracks formed in the display cover by measuring vibrations the piezoelectric actuators pulse through the display cover.

9. The portable electronic device as recited in claim **1**, further comprising a shock detection system for detecting a shock and passing associated shock information to the processor that uses the associated shock information to identify that the device has sustained a shock likely to form a crack in the display cover.

10. The portable electronic device as recited in claim **9**, wherein the crack detection system only checks for and characterizes cracks when the shock detection system detects a shock or detects movement of the portable electronic device likely to precede a shock.

11. A portable electronic device, comprising:

a housing including a housing component and a display cover;

a display assembly disposed beneath the display cover;

a crack detection sensor arranged adjacent to the display assembly, wherein the crack detection sensor periodically measures light refracted by the display cover during operation of the portable electronic device.

12. The portable electronic device as recited in claim **11**, wherein the crack detection sensor is a first crack detection sensor and the portable electronic device further comprises a second crack detection sensor that provides a greater amount of information about a crack propagating through the display cover than the first crack detection sensor.

13. The portable electronic device as recited in claim **12**, wherein the second crack detection sensor comprises a grid of conductive ink positioned along an interior facing surface of the display cover.

14. The portable electronic device as recited in claim **11**, wherein the crack detection sensor comprises a light source and a light detector, the light source being configured to direct light into the display cover and the light detector being configured to measure the light directed into the display cover by the light source.

15. The portable electronic device as recited in claim **14**, wherein the light emitted by the light source is modulated to help distinguish the emitted light from other light sources.

16. The portable electronic device as recited in claim **15**, further comprising multiple light sources, at least one of the light sources emitting light modulated in a different pattern than the modulation pattern used by the other light sources.

17. An electronic device, comprising:

a device housing;

a display cover overlaying a display assembly disposed within the device housing;

a device orientation system; and

a crack detection system,

wherein the crack detection system is configured to change from a first state to a second state in response to determination by the device orientation system that an event likely to damage the display cover is imminent or has just occurred.

18. The electronic device as recited in claim **17**, wherein when the crack detection system is in the first state, the crack detection system checks for cracks at a first interval substantially longer than a second interval at which the crack detection system checks for cracks in the second state.

19. The electronic device as recited in claim **17**, wherein the crack detection system comprises a first sensor and a second sensor.

20. The electronic device as recited in claim **19**, wherein the first sensor is a touch sensor in contact with an interior facing surface of the display cover.

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